Nuclear Fission Propulsion

Bill Emrich/PS05
205–544–7504
E-mail: bill.emrich@msfc.nasa.gov

Missions to Mars will almost certainly require propulsion systems with performance levels exceeding that of today's best chemical engines. A strong candidate for that propulsion system is the Nuclear Thermal Rocket or NTR. Solid core NTR engines should have specific impulses in the range of 925 sec as opposed to chemical lox/hydrogen engines with specific impulses in the range of 450 sec. NTR's operate by using a nuclear reactor to heat hydrogen propellant to high temperatures and then expelling the resulting exhaust through a nozzle to produce thrust.

In the early 1970's, a nuclear rocket program was instituted called ROVER/NERVA which demonstrated a 75,000-lb thrust class engine. This engine was tested in the Nevada desert by allowing the hot hydrogen propellant exhaust to escape directly into the atmosphere. Such testing would not be permitted in today's regulatory environment; therefore, the current emphasis is on much smaller nuclear engines with thrust levels of less than 15,000 lb. These engines are small enough to be tested in current closed-loop test facilities, thus avoiding the expense of constructing large, expensive test facilities that would be required for the larger engines. High values of thrust can be attained, at the expense of specific impulse, by injecting and burning oxygen in the supersonic portion of the nozzle. Investigations are also being pursued for using these engines in "dual mode" operation—the engine reactor could be used both for thrust and power production. Figure 10 illustrates a nuclear thermal engine. Research is underway with LeRC and LANL to understand the benefits and problems with oxygen augmentation and dual-mode use.

Another nuclear thermal engine concept that is being investigated is the gas core nuclear rocket. This engine concept offers the possibility of even higher performance levels than the solid core nuclear rocket with specific impulses in the order of 1,500 to 5,000 sec. These engines use a fissioning uranium plasma to heat hydrogen gas to ultra-high temperatures before being expelled through a nozzle. The technical difficulties associated with constructing a gas core NTR are formidible. Before a gas core nuclear engine can be constructed, it will be necessary to answer fundamental feasibility questions related to maintaining uranium plasma stability, minimizing uranium plasma loss through the nozzle, and maintaining separation of the hydrogen propellant from the uranium plasma while maximizing their energy exchange. Research is being conducted with LANL to answer some of these gas core issues.

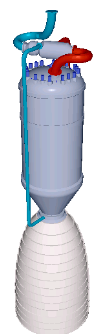

Figure 10.—Nuclear thermal engine.

Sponsor: Advanced Space Transportation Program

Biogaphical Sketch: Bill Emrich is an AST Aerospace Flight Systems engineer. He serves as a project engineer for advanced propulsion systems, developing analytical and design techniques for advanced propulsion systems and defining ancillary propulsion system elements. Emrich received his B.S. at Georgia Institute of Technology, his M.S. at Massachusetts Institute of Technology, and conducted his post graduate work at Princeton University.